

SHORT COMMUNICATION

OBSERVATIONS ON COURTSHIP AND COPULATION OF THE WOLF SPIDER *RABIDOSA SANTRITA* (ARANEAE, LYCOSIDAE)

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ABSTRACT. In this note, I describe courtship and mating behavior of the wolf spider *Rabidosa santrita* (Chamberlin & Ivie 1942) from riparian habitat in southeastern Arizona. Males responded to substrate-borne cues of females with several distinctive behaviors: they walked slowly, following female web draglines; with their palps, they plucked the dragline and/or tapped on the substrate near the dragline; and they performed raises and extensions of legs I, “tapping” the tips while in midair. On substrate previously occupied by another male, these behaviors were either not done or males performed them more rapidly, and for a shorter duration. Males initiated courtship, which consisted of taps or short strokes of legs I of the female by the male’s legs I. Copulation was similar to that described for other species of *Rabidosa*. Males inserted one palp at a time, performed one hematodochal expansion per insertion, moistened the palp following insertion, and alternated palps for each insertion. Copulation lasted from 35 min to >1 h.

Keywords: Courtship behavior, mating behavior, pheromones, substrate-borne cues, dragline, silk

The genus *Rabidosa* Roewer 1960 comprises five species of medium to large sized wolf spiders found primarily in the United States (Brady & McKinley 1994). For this genus, behaviors related to courtship and mating have been described most thoroughly for the widespread species *R. rabida* (Walckenaer 1837). Female *R. rabida* produce pheromone-laden silk draglines, which males use to locate females (Tietjen & Rovner 1982). Once an encounter has occurred, a male may use both visual and auditory signals during courtship (Rovner 1968, 1975). A male that courts successfully mounts the female so they face in opposite directions, inserts a palp into one side of the female’s epigynum, and expands the hematodocha once to force sperm into the female’s copulatory tubes. As the male shifts to the opposite side, the female responds by rotating her abdomen, enabling the male to insert his other palp in the opposite side of the epigynum (Rovner 1968, 1971). Males repeat this process a number of times and copulation can last for over an hour (Rovner 1972; Stratton et al. 1996).

Courtship and mating behaviors are poorly known for the remaining *Rabidosa* species. As for *R. rabida*, male *R. punctulata* (Hentz 1844) locate females by following their draglines (Tietjen & Rovner 1982). Copulatory behavior in *R. punctulata* and *R. hentzi* (Banks 1904) also resembles that of *R. rabida*, as males assume the same orientation to the female and perform one insertion and he-

matodochal expansion before switching to the opposite side of the epigynum (Stratton et al. 1996). No description of courtship or mating behaviors exists for the other two species, *R. carrana* (Bryant 1934) and *R. santrita* (Chamberlin & Ivie 1942).

Rabidosa santrita is the only member of the genus found in the western United States and is considered the sister species of *R. rabida* (Brady & McKinley 1994). Kronk & Riechert (1979) have shown that both sexes of *R. santrita* prefer woodland (grassy) areas as juveniles but move closer to streams as adults, and Stratton et al. (2004) have examined locomotion of this species on the water’s surface. However, little else is known of this species. In this note, I characterize behaviors exhibited by male *R. santrita* in the presence of chemical cues from male or female conspecifics. I next outline courtship and copulatory behaviors observed in a series of laboratory trials and compare the results to observations of other *Rabidosa*.

I collected 26 *R. santrita* (15 males, 11 females) on 17 June 2004 from the cobble zone along Cave Creek on the grounds of the American Museum of Natural History’s Southwestern Research Station, located in the Chiricahua Mountains southwest of Portal, Cochise Co., Arizona (31.9147°N, 109.14795°W). Spiders were collected at night while active on the cobble surface, and all were in the penultimate or antepenultimate instar when captured. Spiders were housed individually in 0.95 l

translucent containers fitted with a perforated lid. Each container had a substrate of moistened peat moss ~1 cm deep and a crumpled piece of paper towel to serve as a refuge. I offered spiders 2–3 juvenile crickets weekly. The laboratory was kept on a 13L:11D photoperiod and at a temperature of 21–24 °C. Voucher specimens have been deposited at the Denver Museum of Nature and Science.

By mid-September, all spiders had undergone their final molt. Between 7–28 October, I performed a series of trials to examine male behaviors on substrate previously occupied by either an adult male or adult female conspecific to determine if males could detect and differentiate between chemical cues left by either sex. I used 15 males for these trials, testing each on both male- and female-occupied substrates. I randomized the order of substrate presentation across males.

Test chambers were 10 × 10 × 8.5 cm transparent plastic containers with a layer of moistened peat moss ~2 cm deep and fitted with a perforated lid. I placed a single adult male or female (the “cue” spider) into each chamber and kept it there for 4 days, during which time all spiders deposited silk and (presumably) excreta. Prey were not available to the cue spiders in the test chamber; however, each had been offered crickets 24 h before introduction to the test chamber. A total of eight cue females (1–3 trials per spider) and 10 cue males (1–2 trials per spider) were used.

To begin a trial, I removed the cue spider and then introduced a single male “trial” spider into the center of a test chamber. Each trial spider had been fed the same day as the cue spider, and had been held in a large centrifuge tube for 15–30 min before being placed in the test chamber. I then observed each trial spider for 1 h. All trials were conducted between 1000 and 1330 h. Following a trial, I thoroughly cleaned test chambers and lids with warm water, swabbed all surfaces with ethanol, and allowed them to air dry before re-use with another cue spider.

Male behaviors on substrate previously occupied by a female differed from those on substrate previously occupied by another male. In the following, I provide general qualitative descriptions of male behaviors on substrates with each type of cue; however, individual males differed somewhat in the order in which behaviors were performed, and not every male performed each of the behaviors described for a particular substrate.

On substrate previously occupied by a female, males usually remained stationary for several minutes after introduction to the test chamber. Once active, males performed several distinctive behaviors on encountering female cues (most often draglines). First, males were seldom completely immobile and, when walking, moved at a slow pace;

running or normal-paced locomotion was not observed after contact with female cues.

Second, males performed several actions with their palps. One action involved pulling, or plucking, on the dragline, and males typically alternated palps while performing this behavior. This may be a form of trail following behavior, as described for *R. punctulata* and *R. rabida* (Tietjen & Rovner 1982). Males also tapped the substrate on or near the dragline, again with an alternation between palps. This appears to be chemoexploratory behavior, again similar to behaviors observed in *R. punctulata* and *R. rabida* (Tietjen & Rovner 1982). Finally, males occasionally touched their ventral body surface with one palp or with both palps simultaneously.

A third action observed on female-occupied substrate involved raising and extension of legs I. This behavior began when a stationary or slowly moving male raised a single leg I (or, less frequently, both first legs) to an angle of ~45–80° with the substrate. When fully raised, the leg was held straight; this position could be maintained for up to a minute, although the duration was typically <10 s. The leg was then brought down toward the ground while fully extended forward. Shortly after this downward motion began, males typically jerked or “tapped” the metatarsus and tarsus several times (what I have called an “air tap”). Males generally performed this behavioral sequence multiple times within a bout, either by alternating legs I or, less commonly, by repeatedly using the same leg. Rarely, males raised and extended a leg II, either alone or in conjunction with leg I. However, air taps were never performed by leg II. This overall sequence in *R. santrita* differed from leg I extensions of *R. rabida* in several ways (Rovner 1968), notably the way the leg was held when raised (in *R. rabida* it is held in a flexed position) and the presence of air tapping (which is absent in *R. rabida*).

Males placed in contact with conspecific male cues were generally immobile for a large portion of the observation period, often while remaining stationary on the cue male’s silk. However, when active, males moved more rapidly than when in the presence of female cues. Many of the trial males tapped and/or plucked at cue male draglines with their palps and performed leg I raises and extensions, but these always differed from similar behaviors done in the presence of female cues. Males performed both palpal plucking/tapping and leg I raises more rapidly and for a shorter duration on male-occupied substrate. I never observed air tapping in this context.

Overall, 14 of 15 males performed each distinctive courtship behavior (slow movement; slower palpal plucking and tapping; multiple leg I raises and extensions with air taps) in the presence of female cues, while none of the males performed these

behaviors in the presence of male cues. The male that did not respond to female cues climbed into a corner of the test chamber and remained motionless for the entire observation period.

In a second set of trials, I examined courtship and mating behaviors of *R. santrita*, using six pairs of virgin spiders (although each male had prior exposure to female cues during chemosensory trials). I conducted trials on 2–3 December 2004, between 0930 and 1300 h. For these trials, I used $30 \times 17 \times 10$ cm test chambers fitted with a non-perforated lid and with ~ 2 cm of moistened peat moss as a substrate. A female, which had been offered 2–3 crickets the previous day, was introduced into a chamber and allowed to deposit silk and excreta for 24 h. I then removed the lid, added a male to the half of the test chamber not occupied by the female, and observed the pair for 1 h. As with the chemosensory trials, males were held in centrifuge tubes for 15–30 min before introduction to the test chamber. Spiders still engaged in copulation at the end of 1 h were allowed to continue mating for up to an additional 1 h but no observations were made during this period.

In all trials, males encountered female draglines, with five of the six males orienting in the female's general direction on first movement. All males performed behaviors identical to those seen in the female-cue chemosensory trials. In particular, males slowly followed a dragline, tapped and/or plucked it with their palps, and performed leg I raises and extensions with air taps. Females appeared able to detect the male's approach at a distance of 5–10 cm. Most females (four of six) simply turned towards the male; however, one female moved forward 2–3 cm as the male approached, and another retreated ~ 5 cm. In two cases, the male performed palpal taps at a faster rate as he neared the female.

Two distinct behavioral sequences occurred as a male neared a female. In three trials, the female assumed a posture in which she raised her body well off the substrate and lifted her legs I (and, in the case of one female, legs II) straight upward. This posture occurred when the male was ~ 2 –5 cm away, and the female remained in this position until contacted by the male. On contact with the male's leg I, the female lunged at the male, who rapidly retreated; the female then remained in this raised-body posture for several minutes. This sequence (male approach followed by female raised-body posture and lunge) was repeated 2–3 times in each trial, but no female appeared to bite a male. It seems likely that the female's behavior represents an aggressive response to the male, since no copulations occurred in these three trials and the raised-body posture was not performed by females who did copulate.

In the other three trials, the male successfully copulated with the female. Courtship was always

initiated when the male's extended leg I touched the female's leg I. This contrasts with the initiation sequence in *R. rabida*, in which the female always made first contact (Rovner 1972). The male repeatedly touched the female's leg(s) I with his leg(s) I for 1–2 min. During this period the female lowered her entire body close to the substrate and extended legs I and II in front of her along the ground. Rovner (1972) describes a similar lowering of the cephalothorax in *R. rabida*. The male then climbed onto the female in the standard lycosid position (Type 3; Foelix 1996), facing her abdomen, and began palpal insertions. Two short video clips of one copulation sequence are available online at "iweb.tntech.edu/cabrown/Rabidosa1.wmv" and "iweb.tntech.edu/cabrown/Rabidosa2.wmv" (or contact the author).

Copulation in *R. santrita* followed the typical pattern found in *Rabidosa* (Stratton et al. 1996). The male inserted one palp at a time, the left into the left epigynal opening and the right into the right epigynal opening. After insertion, the palpal hematodocha expanded a single time. During the time the palp was engaged with the epigynum, the male vibrated his abdomen up and down at a moderate rate. After removal of the palp from the epigynum, the male pulled it several times between his chelicerae, an action termed palpal moistening by Rovner (1972). Palpal moistening was only rarely skipped. The male then shifted to the other side, triggering rotation of the female's abdomen, and inserted the opposite palp into the epigynum. This pattern of insertion and hematodochal expansion by alternating palps continued for 35 min in one pair, and for >1 h in the other two pairs. These times are similar to those reported for *R. hentzi* and *R. rabida* (Rovner 1972; Stratton et al. 1996). For the pair in which I observed the end of copulation, the male dismounted from the female and walked rapidly away, while the female remained motionless for ~ 5 min. These two spiders then re-encountered one another ~ 15 min after the end of copulation, resulting in the female assuming a raised-body posture and lunging at the male. Cannibalism of the male occurred in one of the other trials. Since I did not observe the end of copulation or the attack on the male, I do not know if cannibalism occurred immediately after mating or upon re-encounter.

All females that mated produced egg sacs, at 7, 24, and 84 d post-copulation. Only the sac laid at 24 d produced spiderlings; the first-laid sac failed when the female died and the last-laid sac was small and dropped by the female. Two of the non-mated females also produced egg sacs, at 92 and 106 d post-trial. Both sacs were small and dropped by the females. These results may in part reflect the age of the spiders when mating trials were conducted (2 months after the final molt), if mating success of either males or females declines with age (e.g., Hu & Morse 2004).

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LITERATURE CITED

- Brady, A.R. & K.S. McKinley. 1994. Nearctic spiders of the wolf spider genus *Rabidosa* (Araneae: Lycosidae). *Journal of Arachnology* 22:138–160.
- Foelix, R.F. 1996. *Biology of Spiders*. Second Edition. Oxford University Press, New York. 330 pp.
- Hu, H.H. & D.H. Morse. 2004. The effect of age on encounters between male crab spiders. *Behavioral Ecology* 15:883–888.
- Kronk, A.E. & S.E. Riechert. 1979. Parameters affecting the habitat choice of a desert wolf spider, *Lycosa santrita* Chamberlin and Ivie. *Journal of Arachnology* 7:155–166.
- Rovner, J.S. 1968. An analysis of display in the lycosid spider *Lycosa rabida* Walckenaer. *Animal Behaviour* 16:358–369.
- Rovner, J.S. 1971. Mechanisms controlling copulatory behavior in wolf spiders (Araneae: Lycosidae). *Psyche* 78:150–165.
- Rovner, J.S. 1972. Copulation in the lycosid spider (*Lycosa rabida* Walckenaer): a quantitative study. *Animal Behaviour* 20:133–138.
- Rovner, J.S. 1975. Sound production by Nearctic wolf spiders: a substratum-coupled stridulatory mechanism. *Science* 190:1309–1310.
- Stratton, G.E., E.A. Hebets, P.R. Miller & G.L. Miller. 1996. Pattern and duration of copulation in wolf spiders (Araneae, Lycosidae). *Journal of Arachnology* 24:186–200.
- Stratton, G.E., R.B. Suter & P.R. Miller. 2004. Evolution of water surface locomotion by spiders: a comparative approach. *Biological Journal of the Linnean Society* 81:63–78.
- Tietjen, W.J. & J.S. Rovner. 1982. Chemical communication in lycosids and other spiders. Pp. 249–278. *In* *Spider Communication: Mechanisms and Ecological Significance*. (P.N. Witt & J.S. Rovner, eds.). Princeton University Press, Princeton, New Jersey.

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